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(54) Electron-beam external butt welding of tubes

(57) A machine for the electron-beam external butt welding of tubes comprises *n* radially directed electron guns (50 to 55) arranged on a fixed support, each gun having local means for the displacement of the electron beam emitted thereby to cause said electron beam to sweep a different area of the annular surface (1) of contact of the tubes, each area extending over a fraction of the annular surface at least equal to $1/n$. The displacement means may comprise means for limited translatory or pivotal displacement of the respective gun and/or means for deflection of the beam of the gun.

As described, the guns are mounted on the wall (19) of a vacuum chamber. For translatory displacement, each gun is mounted on a plate (26, Fig. 3) which slides sealingly over an opening in the wall (19). For pivotal displacement, each gun is mounted in an opening in the wall (19) with a bellows (36, Fig. 4) extending between the wall and gun.

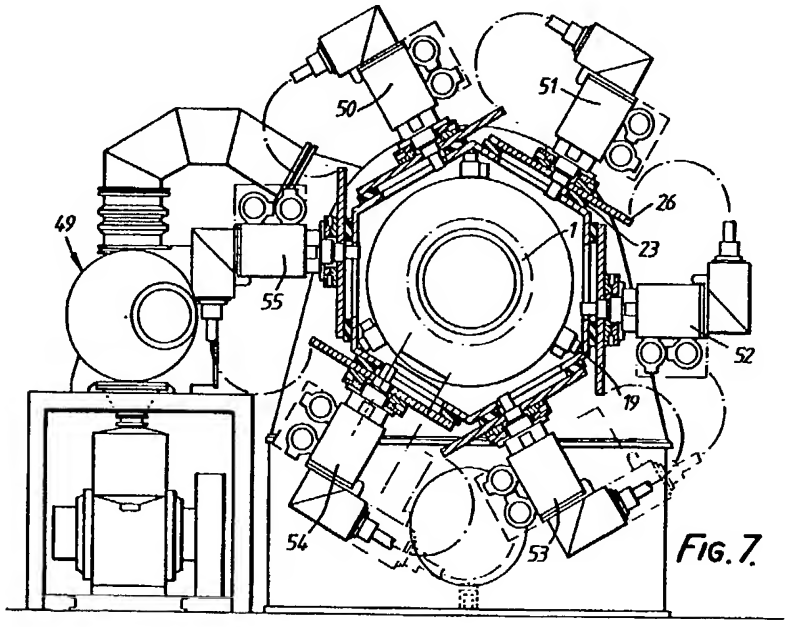

FIG. 7.

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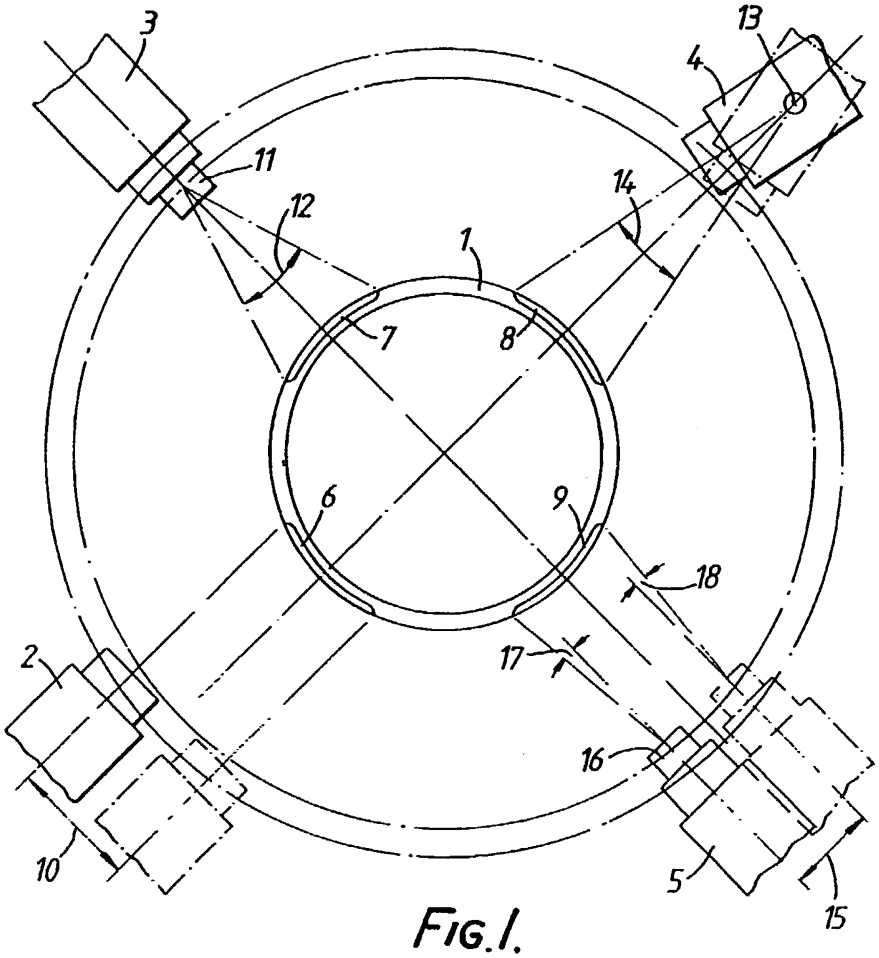


FIG. 1.

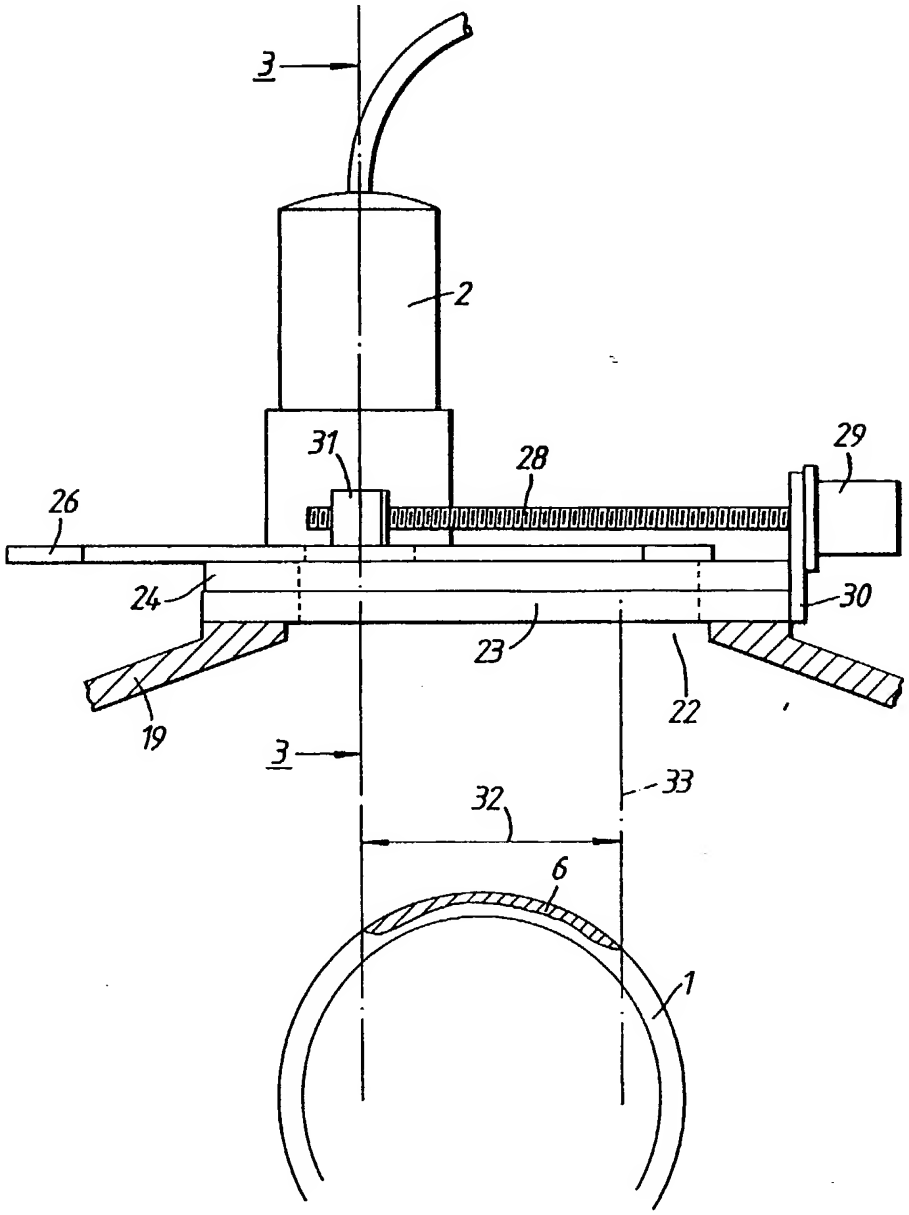
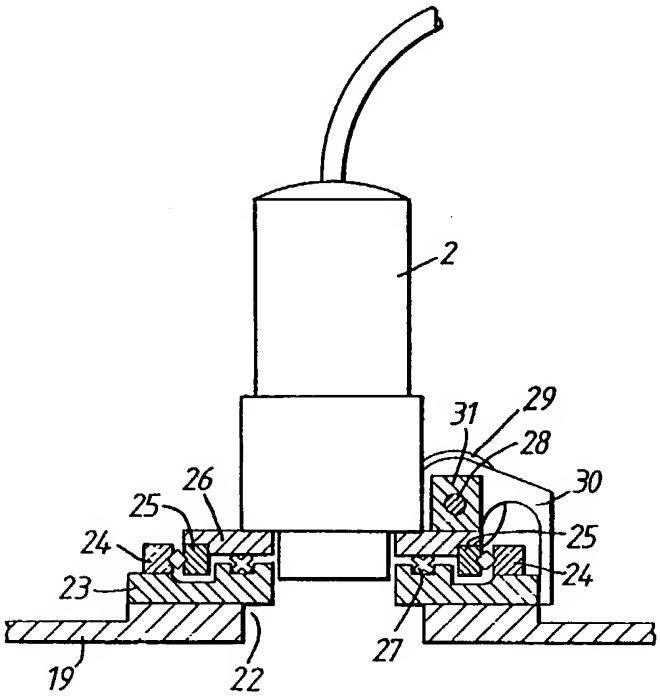


FIG. 2.



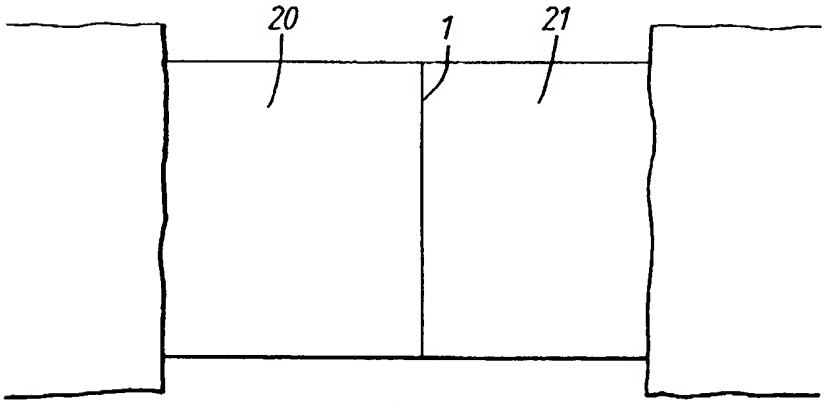


FIG. 3.

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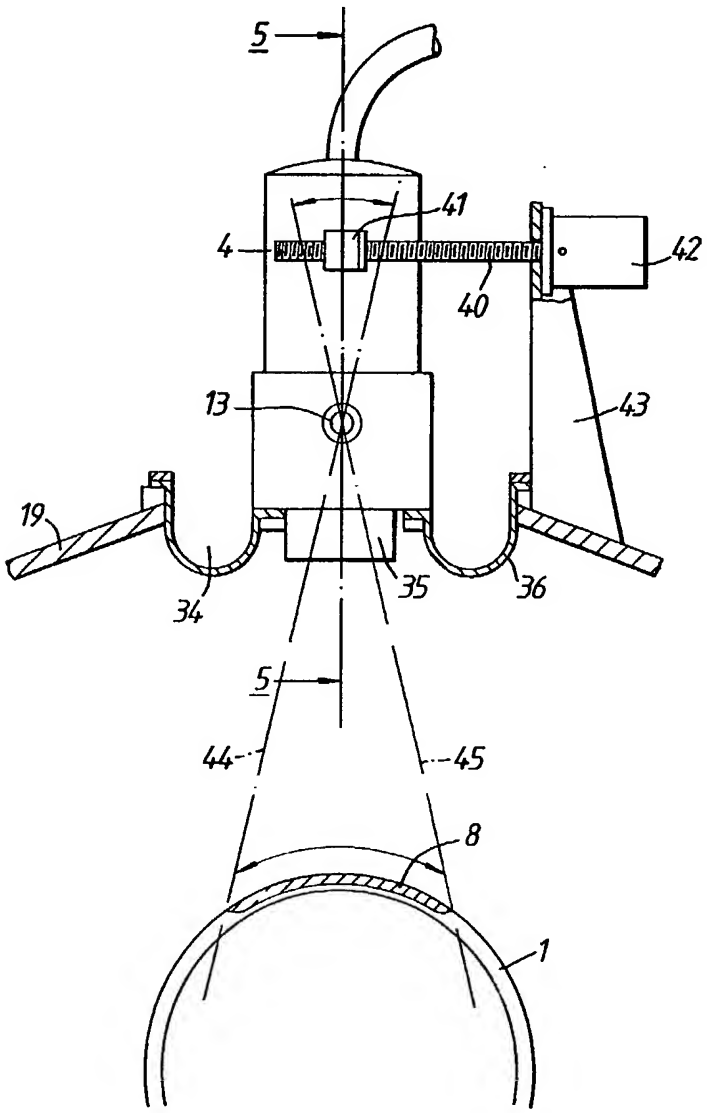
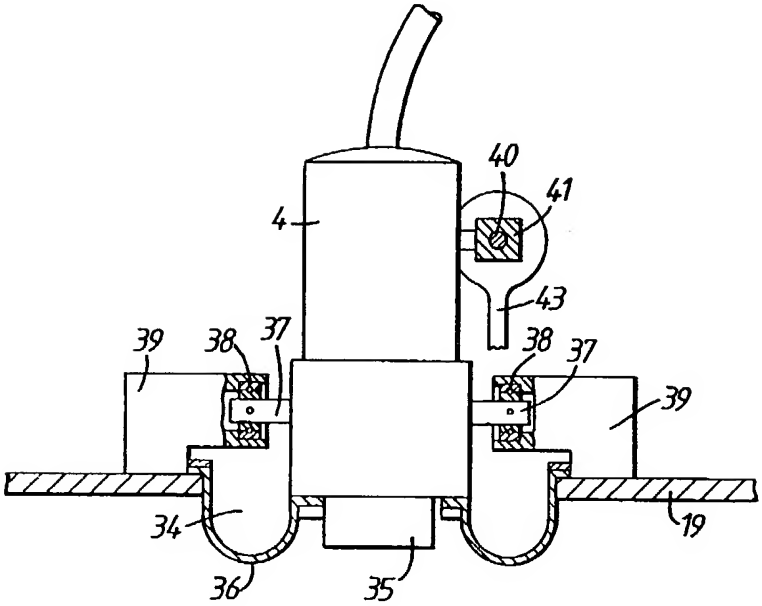


FIG. 4.



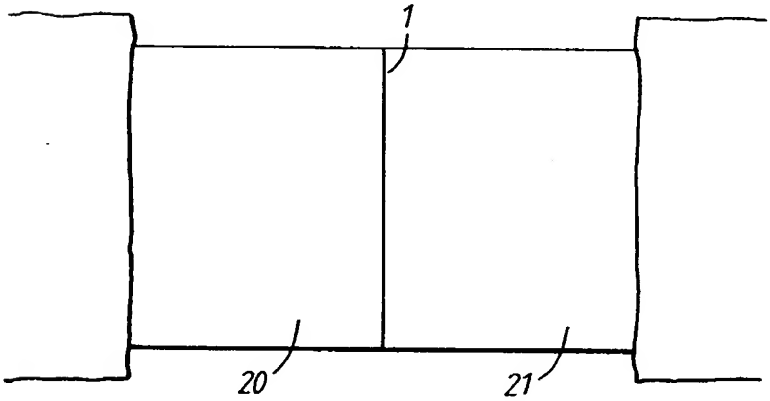


FIG. 5.

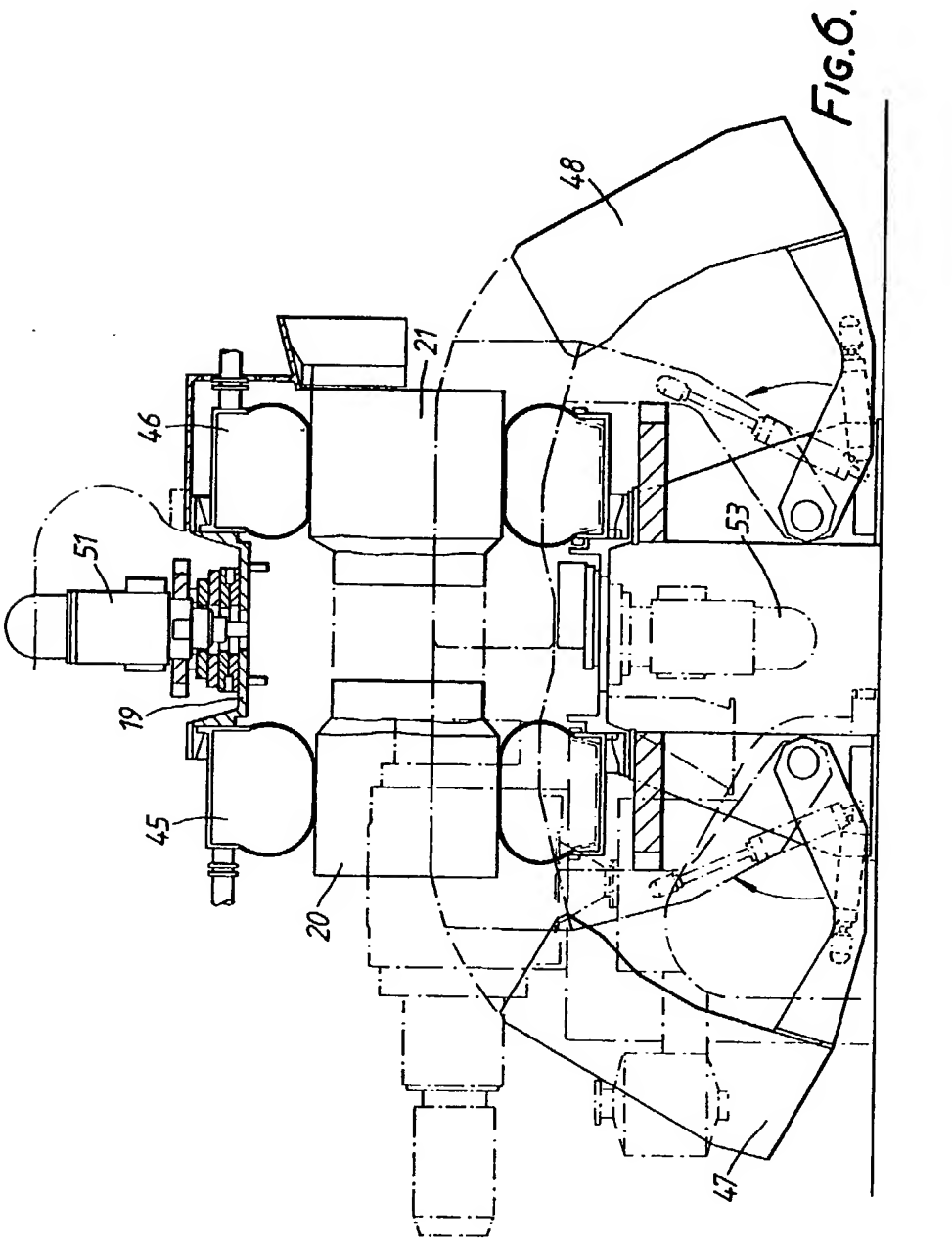


FIG.6.

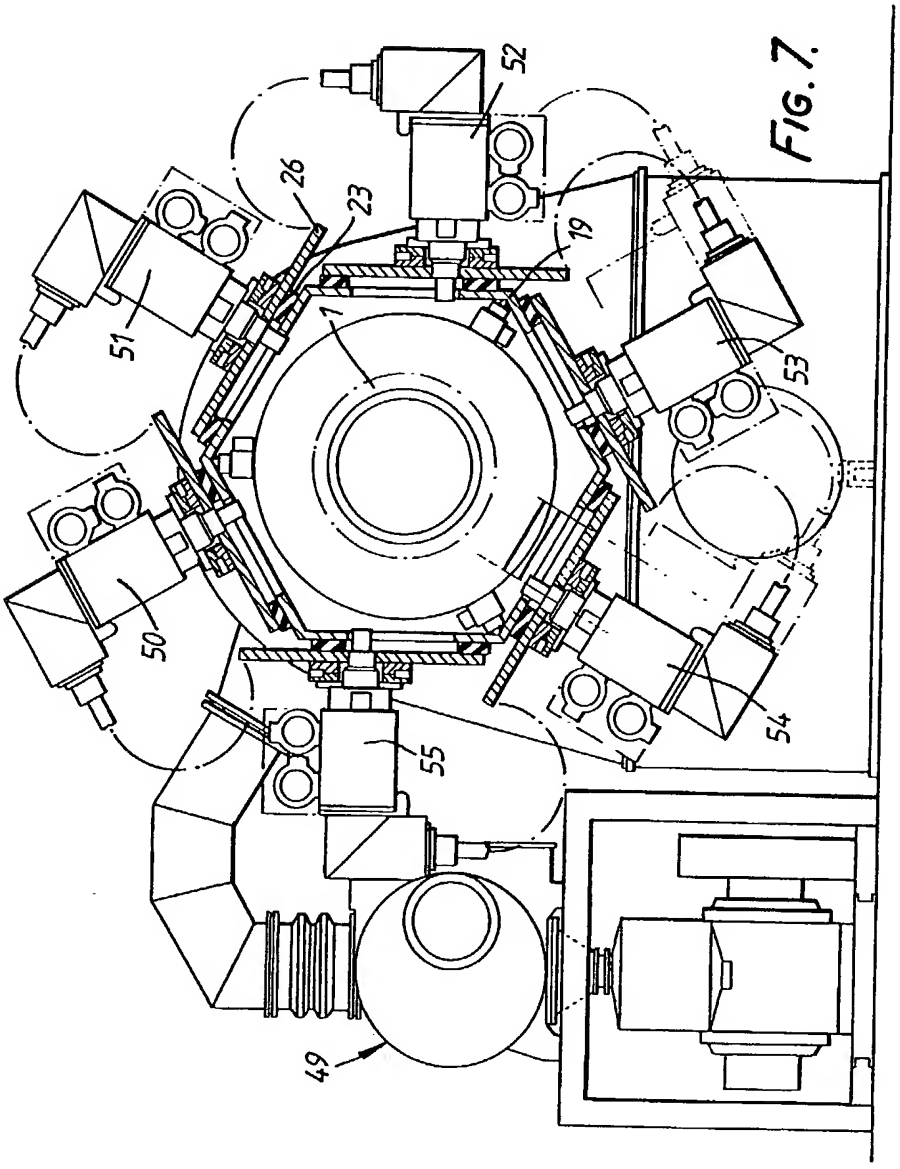


FIG. 7.

SPECIFICATION

A machine for electron-beam external butt welding of tubes

The present invention relates to an electron-beam welding machine intended to be disposed outside two tubes placed end to end to join them by welding.

It is known that it is possible to dispose around tubes, which are laid end to end, at least one radially directed electron gun contained in a vacuum chamber surrounding the junction zone of the two tubes, and to drive this gun rotationally in order to make a weld over the entire circumference of the junction zone of the tubes.

This results in particular in a large volume to be placed under vacuum, considerable equipment having to be rotated, and the need to install rotating seals.

According to the invention there is provided a machine for the external electron beam butt welding of tubes, comprising a number n of electron guns distributed over a circumference, each gun being adapted to emit at an emitter end an electron beam directed radially inwardly and being carried by a support structure for surrounding the tubes externally, when the tubes are disposed end to end with an annular surface of contact, wherein said support structure is fixed and displacement means are locally associated with each electron gun for effecting a limited displacement of the electron beam produced thereby so as to cause each electron beam to sweep over a different area of the annular contact surface, the respective area extending over a fraction of the annular surface equal to at least $1/n$.

The number n is selected to be the greater, the larger the diameter of the tubes to be welded.

The displacement means may enable the associated electron gun to make a translatory or pivotal movement.

Alternatively the displacement means may comprise means for deflecting the electron beam produced by the associated electron gun, the gun remaining fixed.

In a modification the displacement means comprise means for the translatory displacement of the associated electron gun, and means for deflecting the electron beam produced by the electron gun, such that the deflection means extend the range swept by the electron beam of the electron gun under the action of the translatory displacement means.

Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings.

In the drawings:

Figure 1 shows schematically four different electron guns with different means for local displacement of the electron beams emitted thereby, and their zones of action on the annular surface of contact between two tubes which are to be butt welded;

Figure 2 is an axial view of an embodiment of electron gun of the translatory displacement type, mounted around said annular surface, and

Figure 3 shows a transverse view partly in section on the line 3-3 in Figure 2;

Figure 4 is an axial view of an embodiment of a pivoting electron gun mounted around the annular contact surface, and

Figure 5 shows a transverse view partly in section on the line 5-5 in Figure 4;

Figure 6 is a side view in axial section of an embodiment of a welding machine installed around two tubes which are to be butt welded; and

Figure 7 is an axial view of the machine shown in Figure 6.

Figure 1 shows an annular surface 1 of contact between two tubes to be welded, and four electron guns 2 to 5 having different means for causing displacement of the electron beam produced thereby and intended for the external welding of the tubes over a portion of the outer circumference of the annular surface 1, the portions being designated 6 to 9 respectively. This illustration has been selected to show clearly the manner in which the different electron guns operate. If it were actually required to effect the external welding of the tubes, the same type of guns would preferably have been selected and, in any case, their number would have been increased so that the portions 6, 7, 8, 9 would not be spaced from one another but would cover the entire external circumference of the surface 1. As a generality, if n electron guns are provided, each gun will act on a fraction of the outer circumference of surface 1 which is at least equal to $1/n$.

To sweep the portion 6, the gun 2 undergoes translatory displacement perpendicularly to the axis of the tubes and to the radius of the middle position of the gun, over a distance 10. To sweep the portion 7, the electron beam emitted by the gun 3 is subjected by a deflector 11 to a progressive deflection whose amplitude extends over an angle 12 between two maxima in opposite directions. To sweep the portion 8, the gun 4 pivots about an axis 13 to displace the electron beam emitted by it over an angle 14. To sweep the portion 9, the gun 5 undergoes translatory displacement over a distance 15 and it is provided with a deflector 16 bringing about an additional sweep of the electron beam by an angle 17 or 18 at the two ends of the translatory displacement.

Figures 2 and 3 show in greater detail the mounting of an electron gun of the translatory displacement type, such as the gun 2. A support structure in the form of a wall 19 externally bounds the vacuum chamber which sur-

rounds the annular surface 1 of contact between tubes 20, 21, and is provided with circumferentially distributed openings 22 for the guns (only one of which is shown). The section of each opening 22 is substantially rectangular with the length disposed in the circumferential direction and the width in the axial direction -the axial direction being taken as that of the axis of the tubes 20, 21. Each opening 22 is provided with a fixed plate 23, which is provided with a rectangular opening similar to the opening 22 and permitting the passage of the electron beam emitted by the respective gun 2 during its translatory displacement.

The fixed plate 23 carries slide guides 24 cooperating with slides 25 fixed to a movable plate 26 carrying the gun 2. A seal 27 mounted on the fixed plate 23 surrounds the opening in the fixed plate and ensures the leaktightness of the movable plate 26 during the displacement of the latter.

A worm 28 driven rotationally by a motor-reduction gear unit 29 mounted with the aid of a bracket 30 on the fixed plate 23 meshes with a nut 31 fixed to and for translatory movement with the movable plate 26. The worm 28 is directed along the length of the opening formed in the fixed plate 23, so that the axis of the electron beam emitted by the gun 2 can be displaced along the distance 32 between two end positions, one coinciding with the section 3-3 in Figure 2 and the other coinciding with the line 33 shown in Figure 2, the end positions delimiting the portion 6 of the circumference of the surface 1 welded by the electron gun 2.

In the case of the electron gun 5 in Figure 1, the arrival of the gun at the end of its translatory movement triggers the progressive operation of the deflector 16 to enable the electron beam to reach the intended final end position. Similarly, at the start, the deflection is in the opposite direction and is maximum so that the electron beam can move from the initial end position, the deflection being reduced proressively before the gun starts its translatory displacement. The controls necessary for carrying out these processes have not been shown, because they use known conventional techniques.

Figures 4 and 5 show in greater detail the mounting of a pivoting electron gun, such as the gun 4. The same reference 19 has been used for the wall delimiting the vacuum chamber as is used in Figures 2 and 3, but in this case wall 19 is provided with openings 34 (only one of which is shown in Figures 4 and 5) which may have a circular section and are distributed over the circumference of the wall. The emitter end of the electron gun 4 penetrates into the opening 34 and is provided with a focussing lens 35.

Leaktightness between the wall 19 and the gun 4 is provided by a bellows 36 fixed to the wall 19 and to the electron gun 4. The gun 4 is pivotable about pivot axis 13, defined by pivot pins 37 fastened to the gun 4 and mounted in bearings 38 carried by brackets 39 fixed on the wall 19, as can be seen in Figure 5. The gun is driven in its pivoting movement by a worm 40 meshing with a nut 41 fastened to the gun 4, with the interposition of an articulation having a horizontal axis, the worm being driven rotationally by a motor-reduction gear unit 42 carried by pivot pins on a bracket 43 fixed on the wall 19. Dot-dash lines 44 and 45 indicate end positions of the electron beam between which the gun 4 sweeps the area 8 of the annular surface 1. The controls necessary for the pivoting of the gun 4 have not been shown, because they are of conventional design.

Figures 6 and 7 illustrate an example of an external welding machine with translatory displacement of the electron guns.

In Figure 6 it can be seen that the wall 19 may be connected leaktightly to the tubes 20 and 21, e.g. to the concreted portions of the tubes 20, 21, by means of inflatable annular seals 45 and 46 carried by the wall 19. Protectors 47 and 48 protect the interior of the welding machine during the displacement of the tubes 20 and 21. A vacuum is produced inside the chamber bounded by the wall 19 by a pumping installation 49 shown in Figure 7.

Figure 7 makes it possible to see all of the electron guns, e.g. the six guns 50 to 55 in this embodiment which are distributed circumferentially on the wall 19, each of them welding one sixth of the circumference of the annular contact surface 1.

A similar arrangement of electron guns can be used in the case of guns whose welding range is obtained by deflection of the electron beam or by the pivoting of the guns. The mounting of the guns on the wall 19 facilitates division of the casing provided thereby into a plurality of articulated opening sectors, for example three sectors, in order to facilitate the positioning of the welding machine around the tubes 20 and 21. It is then necessary to provide seals between the various sectors in order to form a leaktight enclosure by closing these sectors around the tubes 20 and 21. Numerous other alternative arrangements can obviously be adopted in the application of the invention.

There is thus provided an external welding machine which permits the rapid electron-beam butt welding of two tubes while placing only a small volume under vacuum, eliminating any substantial displacement of equipment, and avoiding rotating seals. In addition, the vacuum chamber may optionally be divided into opening sectors.

CLAIMS

1. A machine for the external electron beam

butt welding of tubes, comprising a number *n* of electron guns distributed over a circumference, each gun being adapted to emit at an emitter end an electron beam directed radially inwardly and being carried by a support structure for surrounding the tubes externally, when the tubes are disposed end to end with an annular surface of contact, wherein said support structure is fixed and displacement means are locally associated with each electron gun for effecting a limited displacement of the electron beam produced thereby so as to cause each electron beam to sweep over a different area of the annular contact surface, the respective area extending over a fraction of the annular surface equal to at least $1/n$.

2. A machine according to claim 1, wherein said displacement means comprise means for deflecting the electron beam produced by the respective electron gun associated with said displacement means, the electron gun remaining fixed.

3. A machine according to claim 1, wherein said displacement means comprise means for displacing the respective electron gun associated with said displacement means for causing said gun to make either a translatory or a pivotal movement.

4. A machine according to claim 1, wherein said displacement means comprise means for the translatory displacement of the respective electron gun associated with said displacement means, and means for deflecting the electron beam produced by said electron gun, said deflecting means in use extending the portion of the annular contact surface swept by the electron beam through the action of said translatory displacement means.

5. A machine according to any one of the preceding claims, wherein said support structure is provided with openings, with each of which the emitter end of one of said electron guns is sealingly associated, and with annular seals for application against a respective one of the tubes which are to be welded.

6. A machine for the external electron beam butt welding of tubes substantially as herein described with reference to the accompanying drawings.

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